

STRANGE MESONS ($S = \pm 1$, $C = B = 0$)

$K^+ = u\bar{s}$, $K^0 = d\bar{s}$, $\bar{K}^0 = \bar{d}s$, $K^- = \bar{u}s$, similarly for K^* 's

K^\pm

$$I(J^P) = \frac{1}{2}(0^-)$$

Mass $m = 493.677 \pm 0.016$ MeV [a] ($S = 2.8$)

Mean life $\tau = (1.2380 \pm 0.0021) \times 10^{-8}$ s ($S = 1.9$)

$$c\tau = 3.712$$
 m

Slope parameter g [b]

(See Particle Listings for quadratic coefficients and alternative parametrization related to $\pi\pi$ scattering)

$$K^\pm \rightarrow \pi^\pm \pi^+ \pi^- g = -0.21134 \pm 0.00017$$

$$(g_+ - g_-) / (g_+ + g_-) = (-1.5 \pm 2.2) \times 10^{-4}$$

$$K^\pm \rightarrow \pi^\pm \pi^0 \pi^0 g = 0.626 \pm 0.007$$

$$(g_+ - g_-) / (g_+ + g_-) = (1.8 \pm 1.8) \times 10^{-4}$$

K^\pm decay form factors [c,d]

Assuming μ -e universality

$$\lambda_+(K_{\mu 3}^+) = \lambda_+(K_{e3}^+) = (2.97 \pm 0.05) \times 10^{-2}$$

$$\lambda_0(K_{\mu 3}^+) = (1.95 \pm 0.12) \times 10^{-2}$$

Not assuming μ -e universality

$$\lambda_+(K_{e3}^+) = (2.98 \pm 0.05) \times 10^{-2}$$

$$\lambda_+(K_{\mu 3}^+) = (2.96 \pm 0.17) \times 10^{-2}$$

$$\lambda_0(K_{\mu 3}^+) = (1.96 \pm 0.13) \times 10^{-2}$$

K_{e3} form factor quadratic fit

$$\lambda'_+(K_{e3}^\pm) \text{ linear coeff.} = (2.49 \pm 0.17) \times 10^{-2}$$

$$\lambda''_+(K_{e3}^\pm) \text{ quadratic coeff.} = (0.19 \pm 0.09) \times 10^{-2}$$

$$K_{e3}^+ |f_S/f_+| = (-0.3^{+0.8}_{-0.7}) \times 10^{-2}$$

$$K_{e3}^+ |f_T/f_+| = (-1.2 \pm 2.3) \times 10^{-2}$$

$$K_{\mu 3}^+ |f_S/f_+| = (0.2 \pm 0.6) \times 10^{-2}$$

$$K_{\mu 3}^+ |f_T/f_+| = (-0.1 \pm 0.7) \times 10^{-2}$$

$$K^+ \rightarrow e^+ \nu_e \gamma |F_A + F_V| = 0.133 \pm 0.008 \quad (S = 1.3)$$

$$K^+ \rightarrow \mu^+ \nu_\mu \gamma |F_A + F_V| = 0.165 \pm 0.013$$

$$K^+ \rightarrow e^+ \nu_e \gamma |F_A - F_V| < 0.49$$

$$K^+ \rightarrow \mu^+ \nu_\mu \gamma |F_A - F_V| = -0.24 \text{ to } 0.04, \text{ CL} = 90\%$$

Charge Radius

$$\langle r \rangle = 0.560 \pm 0.031$$
 fm

CP violation parameters

$$\Delta(K_{\pi ee}^\pm) = (-2.2 \pm 1.6) \times 10^{-2}$$

$$\Delta(K_{\pi \mu \mu}^\pm) = 0.010 \pm 0.023$$

$$\Delta(K_{\pi \pi \gamma}^\pm) = (0.0 \pm 1.2) \times 10^{-3}$$

$$A_{FB}(K_{\pi \mu \mu}^\pm) = \frac{\Gamma(\cos(\theta_{K\mu}) > 0) - \Gamma(\cos(\theta_{K\mu}) < 0)}{\Gamma(\cos(\theta_{K\mu}) > 0) + \Gamma(\cos(\theta_{K\mu}) < 0)} < 2.3 \times 10^{-2}, \text{ CL} = 90\%$$

NODE=MXXX020

NODE=S010

NODE=S010M;DTYPE=M

NODE=S010T;DTYPE=T

NODE=S010CTA;DTYPE=C;OUR EVAL

CLUMP=S

NODE=S010GT;DTYPE=s;CLUMP=S

NODE=S010DG;DTYPE=s;CLUMP=S

NODE=S010GTP;DTYPE=s;CLUMP=S

NODE=S010DG0;DTYPE=s;CLUMP=S

CLUMP=F

NODE=S010L+E;DTYPE=f;CLUMP=F

NODE=S010LE2;DTYPE=f;CLUMP=F;OUR EVAL; \rightarrow UNCHECKED \leftarrow

NODE=S010LM1;DTYPE=f;CLUMP=G;OUR EVAL; \rightarrow UNCHECKED \leftarrow

NODE=S010LM2;DTYPE=f;CLUMP=G;OUR EVAL; \rightarrow UNCHECKED \leftarrow

NODE=S010L01;DTYPE=f;CLUMP=G;OUR EVAL; \rightarrow UNCHECKED \leftarrow

NODE=S010LPE;DTYPE=f;CLUMP=H

NODE=S010LQE;DTYPE=f;CLUMP=H

NODE=S010FS;DTYPE=f;CLUMP=H

NODE=S010FT;DTYPE=f;CLUMP=H

NODE=S010FSM;DTYPE=f;CLUMP=H

NODE=S010FTM;DTYPE=f;CLUMP=H

NODE=S010F+E;DTYPE=f;CLUMP=H

NODE=S010F+M;DTYPE=f;CLUMP=H

NODE=S010F-E;DTYPE=f;CLUMP=H

NODE=S010F-M;DTYPE=f;CLUMP=H

CLUMP=R

NODE=S010CR;DTYPE=r;CLUMP=R

CLUMP=C

NODE=S010CPE;DTYPE=s;CLUMP=C

NODE=S010CP;DTYPE=s;CLUMP=C

NODE=S010CPG;DTYPE=s;CLUMP=C

NODE=S010AFB;DTYPE=s

T violation parameters

$$\begin{aligned} K^+ \rightarrow \pi^0 \mu^+ \nu_\mu & \quad P_T = (-1.7 \pm 2.5) \times 10^{-3} \\ K^+ \rightarrow \mu^+ \nu_\mu \gamma & \quad P_T = (-0.6 \pm 1.9) \times 10^{-2} \\ K^+ \rightarrow \pi^0 \mu^+ \nu_\mu & \quad \text{Im}(\xi) = -0.006 \pm 0.008 \end{aligned}$$

K^- modes are charge conjugates of the modes below.

K^+ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ p Confidence level (MeV/c)	
Leptonic and semileptonic modes			
$e^+ \nu_e$	(1.581 ± 0.008) $\times 10^{-5}$	247	NODE=S010;CLUMP=A DESIG=11
$\mu^+ \nu_\mu$	(63.55 ± 0.11) %	S=1.2 236	DESIG=1
$\pi^0 e^+ \nu_e$ Called K_{e3}^+	(5.07 ± 0.04) %	S=2.1 228	DESIG=6
$\pi^0 \mu^+ \nu_\mu$ Called $K_{\mu 3}^+$	(3.353 ± 0.034) %	S=1.8 215	DESIG=5
$\pi^0 \pi^0 e^+ \nu_e$	(2.2 ± 0.4) $\times 10^{-5}$	206	DESIG=24
$\pi^+ \pi^- e^+ \nu_e$	(4.254 ± 0.032) $\times 10^{-5}$	203	DESIG=7
$\pi^+ \pi^- \mu^+ \nu_\mu$	(1.4 ± 0.9) $\times 10^{-5}$	151	DESIG=9
$\pi^0 \pi^0 \pi^0 e^+ \nu_e$	< 3.5×10^{-6}	CL=90% 135	DESIG=44
Hadronic modes			
$\pi^+ \pi^0$	(20.66 ± 0.08) %	S=1.2 205	NODE=S010;CLUMP=B DESIG=2
$\pi^+ \pi^0 \pi^0$	(1.761 ± 0.022) %	S=1.1 133	DESIG=4
$\pi^+ \pi^+ \pi^-$	(5.59 ± 0.04) %	S=1.3 125	DESIG=3
Leptonic and semileptonic modes with photons			
$\mu^+ \nu_\mu \gamma$	[e,f] (6.2 ± 0.8) $\times 10^{-3}$	236	NODE=S010;CLUMP=C DESIG=12
$\mu^+ \nu_\mu \gamma (\text{SD}^+)$	[c,g] (1.33 ± 0.22) $\times 10^{-5}$	—	DESIG=39
$\mu^+ \nu_\mu \gamma (\text{SD}^+ \text{INT})$	[c,g] < 2.7×10^{-5}	CL=90% —	DESIG=81
$\mu^+ \nu_\mu \gamma (\text{SD}^- + \text{SD}^- \text{INT})$	[c,g] < 2.6×10^{-4}	CL=90% —	DESIG=40
$e^+ \nu_e \gamma$	(9.4 ± 0.4) $\times 10^{-6}$	247	DESIG=21
$\pi^0 e^+ \nu_e \gamma$	[e,f] (2.56 ± 0.16) $\times 10^{-4}$	228	DESIG=18
$\pi^0 e^+ \nu_e \gamma (\text{SD})$	[c,g] < 5.3×10^{-5}	CL=90% 228	DESIG=41
$\pi^0 \mu^+ \nu_\mu \gamma$	[e,f] (1.25 ± 0.25) $\times 10^{-5}$	215	DESIG=28
$\pi^0 \pi^0 e^+ \nu_e \gamma$	< 5×10^{-6}	CL=90% 206	DESIG=47
Hadronic modes with photons or $\ell\bar{\ell}$ pairs			
$\pi^+ \pi^0 \gamma (\text{INT})$	(-4.2 ± 0.9) $\times 10^{-6}$	—	NODE=S010;CLUMP=D DESIG=119
$\pi^+ \pi^0 \gamma (\text{DE})$	[e,h] (6.0 ± 0.4) $\times 10^{-6}$	205	DESIG=38
$\pi^+ \pi^0 \pi^0 \gamma$	[e,f] (7.6 ± 6.0) $\times 10^{-6}$	133	DESIG=37
$\pi^+ \pi^+ \pi^- \gamma$	[e,f] (1.04 ± 0.31) $\times 10^{-4}$	125	DESIG=14
$\pi^+ \gamma \gamma$	[e] (1.10 ± 0.32) $\times 10^{-6}$	227	DESIG=17
$\pi^+ 3\gamma$	[e] < 1.0×10^{-4}	CL=90% 227	DESIG=23
$\pi^+ e^+ e^- \gamma$	(1.19 ± 0.13) $\times 10^{-8}$	227	DESIG=118
Leptonic modes with $\ell\bar{\ell}$ pairs			
$e^+ \nu_e \nu \bar{\nu}$	< 6×10^{-5}	CL=90% 247	NODE=S010;CLUMP=E DESIG=33
$\mu^+ \nu_\mu \nu \bar{\nu}$	< 6.0×10^{-6}	CL=90% 236	DESIG=27
$e^+ \nu_e e^+ e^-$	(2.48 ± 0.20) $\times 10^{-8}$	247	DESIG=32
$\mu^+ \nu_\mu e^+ e^-$	(7.06 ± 0.31) $\times 10^{-8}$	236	DESIG=30
$e^+ \nu_e \mu^+ \mu^-$	(1.7 ± 0.5) $\times 10^{-8}$	223	DESIG=48
$\mu^+ \nu_\mu \mu^+ \mu^-$	< 4.1×10^{-7}	CL=90% 185	DESIG=117

**Lepton Family number (*LF*), Lepton number (*L*), $\Delta S = \Delta Q$ (*SQ*)
violating modes, or $\Delta S = 1$ weak neutral current (*S1*) modes**

$\pi^+ \pi^+ e^- \bar{\nu}_e$	<i>SQ</i>	<	1.3	$\times 10^{-8}$	CL=90%	203	DESIG=8
$\pi^+ \pi^+ \mu^- \bar{\nu}_\mu$	<i>SQ</i>	<	3.0	$\times 10^{-6}$	CL=95%	151	DESIG=10
$\pi^+ e^+ e^-$	<i>S1</i>	(	3.00 ± 0.09) $\times 10^{-7}$		227	DESIG=15
$\pi^+ \mu^+ \mu^-$	<i>S1</i>	(	9.4 ± 0.6) $\times 10^{-8}$	S=2.6	172	DESIG=16
$\pi^+ \nu \bar{\nu}$	<i>S1</i>	(	1.7 ± 1.1) $\times 10^{-10}$		227	DESIG=20
$\pi^+ \pi^0 \nu \bar{\nu}$	<i>S1</i>	<	4.3	$\times 10^{-5}$	CL=90%	205	DESIG=50
$\mu^- \nu e^+ e^+$	<i>LF</i>	<	2.1	$\times 10^{-8}$	CL=90%	236	DESIG=31
$\mu^+ \nu_e$	<i>LF</i>	[i] <	4	$\times 10^{-3}$	CL=90%	236	DESIG=34
$\pi^+ \mu^+ e^-$	<i>LF</i>	<	1.3	$\times 10^{-11}$	CL=90%	214	DESIG=29
$\pi^+ \mu^- e^+$	<i>LF</i>	<	5.2	$\times 10^{-10}$	CL=90%	214	DESIG=25
$\pi^- \mu^+ e^+$	<i>L</i>	<	5.0	$\times 10^{-10}$	CL=90%	214	DESIG=45
$\pi^- e^+ e^+$	<i>L</i>	<	6.4	$\times 10^{-10}$	CL=90%	227	DESIG=19
$\pi^- \mu^+ \mu^+$	<i>L</i>	[i] <	1.1	$\times 10^{-9}$	CL=90%	172	DESIG=46
$\mu^+ \bar{\nu}_e$	<i>L</i>	[i] <	3.3	$\times 10^{-3}$	CL=90%	236	DESIG=35
$\pi^0 e^+ \bar{\nu}_e$	<i>L</i>	<	3	$\times 10^{-3}$	CL=90%	228	DESIG=36
$\pi^+ \gamma$	[j] <	2.3		$\times 10^{-9}$	CL=90%	227	DESIG=22

K⁰

$$I(J^P) = \frac{1}{2}(0^-)$$

50% K_S , 50% K_L Mass $m = 497.614 \pm 0.024$ MeV (S = 1.6) $m_{K^0} - m_{K^\pm} = 3.937 \pm 0.028$ MeV (S = 1.8)**Mean Square Charge Radius**

$$\langle r^2 \rangle = -0.077 \pm 0.010 \text{ fm}^2$$

T-violation parameters in K^0 - \bar{K}^0 mixing [d]Asymmetry A_T in K^0 - \bar{K}^0 mixing = $(6.6 \pm 1.6) \times 10^{-3}$ **CPT-violation parameters [d]**

$$\text{Re } \delta = (2.5 \pm 2.3) \times 10^{-4}$$

$$\text{Im } \delta = (-1.5 \pm 1.6) \times 10^{-5}$$

$$\text{Re}(y), K_{e3} \text{ parameter} = (0.4 \pm 2.5) \times 10^{-3}$$

$$\text{Re}(x_-), K_{e3} \text{ parameter} = (-2.9 \pm 2.0) \times 10^{-3}$$

$$|m_{K^0} - m_{\bar{K}^0}| / m_{\text{average}} < 6 \times 10^{-19}, \text{ CL} = 90\% \text{ [k]}$$

$$(\Gamma_{K^0} - \Gamma_{\bar{K}^0})/m_{\text{average}} = (8 \pm 8) \times 10^{-18}$$

Tests of $\Delta S = \Delta Q$

$$\text{Re}(x_+), K_{e3} \text{ parameter} = (-0.9 \pm 3.0) \times 10^{-3}$$

K_S⁰

$$I(J^P) = \frac{1}{2}(0^-)$$

Mean life $\tau = (0.8954 \pm 0.0004) \times 10^{-10}$ s (S = 1.1) Assuming CPTMean life $\tau = (0.89564 \pm 0.00033) \times 10^{-10}$ s Not assuming CPT

$$c\tau = 2.6844 \text{ cm} \quad \text{Assuming CPT}$$

CP-violation parameters [l]

$$\text{Im}(\eta_{+-0}) = -0.002 \pm 0.009$$

$$\text{Im}(\eta_{000}) = (-0.1 \pm 1.6) \times 10^{-2}$$

$$|\eta_{000}| = |A(K_S^0 \rightarrow 3\pi^0)/A(K_L^0 \rightarrow 3\pi^0)| < 0.018, \text{ CL} = 90\%$$

$$CP \text{ asymmetry } A \text{ in } \pi^+ \pi^- e^+ e^- = (-0.4 \pm 0.8)\%$$

NODE=S010;CLUMP=F

DESIG=8

DESIG=10

DESIG=15

DESIG=16

DESIG=20

DESIG=50

DESIG=31

DESIG=34

DESIG=29

DESIG=25

DESIG=45

DESIG=19

DESIG=46

DESIG=35

DESIG=36

DESIG=22

NODE=S011

NODE=S011M;DTYPE=M

NODE=S011DM;DTYPE=D

CLUMP=R

NODE=S011SCR;DTYPE=r;CLUMP=R

CLUMP=C

NODE=S011AT;DTYPE=c;CLUMP=C

CLUMP=K

NODE=S011DRE;DTYPE=k;CLUMP=K

NODE=S011DIM;DTYPE=k;CLUMP=K

NODE=S011YRE;DTYPE=k;CLUMP=K

NODE=S011XRM;DTYPE=k;CLUMP=K

NODE=S011DMM;DTYPE=D

NODE=S011DGM;DTYPE=D

CLUMP=Q

NODE=S011XRP;DTYPE=r;CLUMP=Q

NODE=S012

NODE=S012T;DTYPE=T

NODE=S012T1;DTYPE=t;OUR EVAL;
→ UNCHECKED ←

NODE=S012CTA;DTYPE=C;OUR EVAL

CLUMP=V

NODE=S012E+;DTYPE=v;CLUMP=V

NODE=S012E0;DTYPE=v;CLUMP=V

NODE=S012AE0;DTYPE=v;CLUMP=V

NODE=S012DPA;DTYPE=v;CLUMP=Y

K_S⁰ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)	
Hadronic modes				
$\pi^0 \pi^0$	(30.69 ± 0.05) %	209	NODE=S012210;NODE=S012;CLUMP=A	
$\pi^+ \pi^-$	(69.20 ± 0.05) %	206	DESIG=2	
$\pi^+ \pi^- \pi^0$	($3.5 \begin{array}{l} +1.1 \\ -0.9 \end{array} \times 10^{-7}$)	133	DESIG=1	
			DESIG=8	
Modes with photons or $\ell\bar{\ell}$ pairs				
$\pi^+ \pi^- \gamma$	[f, n] (1.79 ± 0.05) $\times 10^{-3}$	206	NODE=S012;CLUMP=B	
$\pi^+ \pi^- e^+ e^-$	(4.79 ± 0.15) $\times 10^{-5}$	206	DESIG=5	
$\pi^0 \gamma \gamma$	[n] (4.9 ± 1.8) $\times 10^{-8}$	231	DESIG=13	
$\gamma \gamma$	(2.63 ± 0.17) $\times 10^{-6}$	S=3.0	DESIG=14	
			DESIG=6	
Semileptonic modes				
$\pi^\pm e^\mp \nu_e$	[o] (7.04 ± 0.08) $\times 10^{-4}$	229	NODE=S012;CLUMP=C	
			DESIG=11	
CP violating (CP) and $\Delta S = 1$ weak neutral current (S1) modes				
$3\pi^0$	CP	$< 1.2 \times 10^{-7}$	CL=90% 139	NODE=S012;CLUMP=F
$\mu^+ \mu^-$	S1	$< 9 \times 10^{-9}$	CL=90% 225	DESIG=7
$e^+ e^-$	S1	$< 9 \times 10^{-9}$	CL=90% 249	DESIG=3
$\pi^0 e^+ e^-$	S1	[n] ($3.0 \begin{array}{l} +1.5 \\ -1.2 \end{array} \times 10^{-9}$)	230	DESIG=4
$\pi^0 \mu^+ \mu^-$	S1	($2.9 \begin{array}{l} +1.5 \\ -1.2 \end{array} \times 10^{-9}$)	177	DESIG=10
			DESIG=15	

K_L⁰

$$I(J^P) = \frac{1}{2}(0^-)$$

$$\begin{aligned}
 m_{K_L} - m_{K_S} &= (0.5293 \pm 0.0009) \times 10^{10} \text{ } \hbar \text{ s}^{-1} \quad (\text{S} = 1.3) \quad \text{Assuming CPT} \\
 &= (3.484 \pm 0.006) \times 10^{-12} \text{ MeV} \quad \text{Assuming CPT} \\
 &= (0.5289 \pm 0.0010) \times 10^{10} \text{ } \hbar \text{ s}^{-1} \quad \text{Not assuming CPT} \\
 \text{Mean life } \tau &= (5.116 \pm 0.021) \times 10^{-8} \text{ s} \quad (\text{S} = 1.1) \\
 c\tau &= 15.34 \text{ m}
 \end{aligned}$$

Slope parameter g [b]

(See Particle Listings for quadratic coefficients)

$$K_L^0 \rightarrow \pi^+ \pi^- \pi^0: g = 0.678 \pm 0.008 \quad (S = 1.5)$$

K_L decay form factors [d]

Linear parametrization assuming μ -e universality

$$\lambda_+(K_{\mu 3}^0) = \lambda_+(K_{e3}^0) = (2.82 \pm 0.04) \times 10^{-2} \quad (S = 1.1)$$

Quadratic parametrization assuming μ -e universality

$$\begin{aligned}\lambda'_+ (K_{\mu 3}^0) &= \lambda'_+ (K_{e3}^0) = (2.40 \pm 0.12) \times 10^{-2} \quad (S = 1.2) \\ \lambda''_+ (K_{\mu 3}^0) &= \lambda''_+ (K_{e3}^0) = (0.20 \pm 0.05) \times 10^{-2} \quad (S = 1.2) \\ \lambda_0 (K_{\mu 3}^0) &= (1.16 \pm 0.09) \times 10^{-2} \quad (S = 1.2)\end{aligned}$$

Pole parametrization assuming μ - e universality

$$M_V^\mu(K_{\mu 3}^0) = M_V^e(K_{e3}^0) = 878 \pm 6 \text{ MeV} \quad (S = 1.1)$$

NODE=S013

```

NODE=S013D;DTYPE=D;CLUMP=D
NODE=S013D1;DTYPE=D;CLUMP=D;OUR EVAL
NODE=S013D2;DTYPE=D;CLUMP=D;OUR EVAL-->UNCHECKED<-
NODE=S013T;DTYPE=T
NODE=S013CTA;DTYPE=C;OUR EVAL

```

CLUMP=S

NODE=S013GT0;DTYPE=s;CLUMP=S

CLUMP=F

```
NODE=S013L+M;DTYPE=f;CLUMP=F  
NODE=S013L0;DTYPE=f;CLUMP=F
```

```
NODE=S013LPM;DTYPE=f;CLUMP=G  
NODE=S013LQM;DTYPE=f;CLUMP=G  
NODE=S013LZ;DTYPE=f;CLUMP=G
```

```
NODE=S013MVM;DTYPE=f;CLUMP=J  
NODE=S013MS1;DTYPE=f;CLUMP=J;OU  
EVAL:→UNCHECKED←
```

Dispersive parametrization assuming μ -e universality

$$\begin{aligned} \Lambda_+ &= (0.251 \pm 0.006) \times 10^{-1} \quad (S = 1.5) \\ \ln(C) &= (1.75 \pm 0.18) \times 10^{-1} \quad (S = 2.0) \\ K_{e3}^0 \quad |f_S/f_+| &= (1.5^{+1.4}_{-1.6}) \times 10^{-2} \\ K_{e3}^0 \quad |f_T/f_+| &= (5^{+4}_{-5}) \times 10^{-2} \\ K_{\mu 3}^0 \quad |f_T/f_+| &= (12 \pm 12) \times 10^{-2} \\ K_L \rightarrow \ell^+ \ell^- \gamma, K_L \rightarrow \ell^+ \ell^- \ell'^+ \ell'^- &: \alpha_{K^*} = -0.205 \pm 0.022 \quad (S = 1.8) \\ K_L^0 \rightarrow \ell^+ \ell^- \gamma, K_L^0 \rightarrow \ell^+ \ell^- \ell'^+ \ell'^- &: \alpha_{DIP} = -1.69 \pm 0.08 \quad (S = 1.7) \\ K_L \rightarrow \pi^+ \pi^- e^+ e^- &: a_1/a_2 = -0.737 \pm 0.014 \text{ GeV}^2 \\ K_L \rightarrow \pi^0 2\gamma &: a_V = -0.43 \pm 0.06 \quad (S = 1.5) \end{aligned}$$

CP-violation parameters [1]

$$\begin{aligned} A_L &= (0.332 \pm 0.006)\% \\ |\eta_{00}| &= (2.220 \pm 0.011) \times 10^{-3} \quad (S = 1.8) \\ |\eta_{+-}| &= (2.232 \pm 0.011) \times 10^{-3} \quad (S = 1.8) \\ |\epsilon| &= (2.228 \pm 0.011) \times 10^{-3} \quad (S = 1.8) \\ |\eta_{00}/\eta_{+-}| &= 0.9950 \pm 0.0007 [p] \quad (S = 1.6) \\ \text{Re}(\epsilon'/\epsilon) &= (1.66 \pm 0.23) \times 10^{-3} [p] \quad (S = 1.6) \end{aligned}$$

Assuming CPT

$$\begin{aligned} \phi_{+-} &= (43.51 \pm 0.05)^\circ \quad (S = 1.2) \\ \phi_{00} &= (43.52 \pm 0.05)^\circ \quad (S = 1.3) \\ \phi_\epsilon = \phi_{SW} &= (43.52 \pm 0.05)^\circ \quad (S = 1.2) \\ \text{Im}(\epsilon'/\epsilon) &= -(\phi_{00} - \phi_{+-})/3 = (-0.002 \pm 0.005)^\circ \quad (S = 1.7) \end{aligned}$$

Not assuming CPT

$$\begin{aligned} \phi_{+-} &= (43.4 \pm 0.5)^\circ \quad (S = 1.2) \\ \phi_{00} &= (43.7 \pm 0.6)^\circ \quad (S = 1.2) \\ \phi_\epsilon &= (43.5 \pm 0.5)^\circ \quad (S = 1.3) \\ CP \text{ asymmetry } A &\text{ in } K_L^0 \rightarrow \pi^+ \pi^- e^+ e^- = (13.7 \pm 1.5)\% \\ \beta_{CP} \text{ from } K_L^0 \rightarrow e^+ e^- e^+ e^- &= -0.19 \pm 0.07 \\ \gamma_{CP} \text{ from } K_L^0 \rightarrow e^+ e^- e^+ e^- &= 0.01 \pm 0.11 \quad (S = 1.6) \\ j \text{ for } K_L^0 \rightarrow \pi^+ \pi^- \pi^0 &= 0.0012 \pm 0.0008 \\ f \text{ for } K_L^0 \rightarrow \pi^+ \pi^- \pi^0 &= 0.004 \pm 0.006 \\ |\eta_{+-\gamma}| &= (2.35 \pm 0.07) \times 10^{-3} \\ \phi_{+-\gamma} &= (44 \pm 4)^\circ \\ |\epsilon'_{+-\gamma}|/\epsilon &< 0.3, \text{ CL} = 90\% \\ |\text{g}_{E1}| \text{ for } K_L^0 \rightarrow \pi^+ \pi^- \gamma &< 0.21, \text{ CL} = 90\% \end{aligned}$$

T-violation parameters

$$\text{Im}(\xi) \text{ in } K_{\mu 3}^0 = -0.007 \pm 0.026$$

CPT invariance tests

$$\begin{aligned} \phi_{00} - \phi_{+-} &= (0.34 \pm 0.32)^\circ \\ \text{Re}(\frac{2}{3}\eta_{+-} + \frac{1}{3}\eta_{00}) - \frac{A_L}{2} &= (-3 \pm 35) \times 10^{-6} \end{aligned}$$

$\Delta S = -\Delta Q$ in $K_{\mu 3}^0$ decay

$$\begin{aligned} \text{Re } x &= -0.002 \pm 0.006 \\ \text{Im } x &= 0.0012 \pm 0.0021 \end{aligned}$$

NODE=S013LAM;DTYPE=f;CLUMP=L	CLUMP=V
NODE=S013LCM;DTYPE=f;CLUMP=L	CLUMP=V
NODE=S013FS;DTYPE=f;CLUMP=H	CLUMP=V
NODE=S013FT;DTYPE=f;CLUMP=H	CLUMP=V
NODE=S013FTM;DTYPE=f;CLUMP=H	CLUMP=V
NODE=S013ALA;DTYPE=f;CLUMP=H	CLUMP=V
NODE=S013ADA;DTYPE=f;CLUMP=H	CLUMP=V
NODE=S013AV;DTYPE=f;CLUMP=H	CLUMP=V
NODE=S013AL;DTYPE=v;CLUMP=V	CLUMP=V
NODE=S013E00;DTYPE=v;CLUMP=V	CLUMP=V
NODE=S013E-;DTYPE=v;CLUMP=V	CLUMP=V
NODE=S013EP;DTYPE=v;CLUMP=V	CLUMP=V
NODE=S013ER;DTYPE=v;CLUMP=V	CLUMP=V
NODE=S013EPS;DTYPE=v;CLUMP=V	CLUMP=V
NODE=S013F-;DTYPE=v;CLUMP=Z	CLUMP=Z
NODE=S013FOO;DTYPE=v;CLUMP=Z	CLUMP=Z
NODE=S013EPH;DTYPE=v;CLUMP=Z	CLUMP=Z
NODE=S013EPI;DTYPE=v;CLUMP=Z	CLUMP=Z
NODE=S013F+2;DTYPE=v;CLUMP=W;	CLUMP=W
OUR EVAL;→ UNCHECKED ←	
NODE=S013FO2;DTYPE=v;CLUMP=W;	CLUMP=W
OUR EVAL;→ UNCHECKED ←	
NODE=S013EP1;DTYPE=v;CLUMP=W;	CLUMP=W
OUR EVAL;→ UNCHECKED ←	
NODE=S013DPA;DTYPE=v;CLUMP=Y	CLUMP=Y
NODE=S013BCP;DTYPE=v;CLUMP=Y	CLUMP=Y
NODE=S013GCP;DTYPE=v;CLUMP=Y	CLUMP=Y
NODE=S013JT0;DTYPE=v;CLUMP=Y	CLUMP=Y
NODE=S013FT0;DTYPE=v;CLUMP=Y	CLUMP=Y
NODE=S013E+G;DTYPE=v;CLUMP=Y	CLUMP=Y
NODE=S013P+G;DTYPE=v;CLUMP=Y	CLUMP=Y
NODE=S013EPG;DTYPE=v;CLUMP=Y	CLUMP=Y
NODE=S013GE1;DTYPE=v;CLUMP=Y	CLUMP=Y
CLUMP=T	
NODE=S013IXI;DTYPE=f;CLUMP=T	
CLUMP=X	
NODE=S013DF1;DTYPE=v;CLUMP=X;	CLUMP=X
OUR EVAL;→ UNCHECKED ←	
NODE=S013CPT;DTYPE=v;CLUMP=X	CLUMP=X
CLUMP=Q	
NODE=S013REX;DTYPE=Q;CLUMP=Q	CLUMP=Q
NODE=S013IMX;DTYPE=Q;CLUMP=Q	CLUMP=Q

K_L^0 DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level (MeV/c)	p
Semileptonic modes			
$\pi^\pm e^\mp \nu_e$ Called K_{e3}^0 .	[o] $(40.55 \pm 0.11) \%$	S=1.7	229 NODE=S013215;NODE=S013;CLUMP=A DESIG=4
$\pi^\pm \mu^\mp \nu_\mu$ Called $K_{\mu 3}^0$.	[o] $(27.04 \pm 0.07) \%$	S=1.1	216 DESIG=3
$(\pi \mu \text{atom}) \nu$	$(1.05 \pm 0.11) \times 10^{-7}$		188 DESIG=19
$\pi^0 \pi^\pm e^\mp \nu$	[o] $(5.20 \pm 0.11) \times 10^{-5}$		207 DESIG=18
$\pi^\pm e^\mp \nu e^\pm e^-$	[o] $(1.26 \pm 0.04) \times 10^{-5}$		229 DESIG=51
Hadronic modes, including Charge conjugation x Parity Violating (CPV) modes			
$3\pi^0$	$(19.52 \pm 0.12) \%$	S=1.6	139 NODE=S013;CLUMP=B
$\pi^+ \pi^- \pi^0$	$(12.54 \pm 0.05) \%$		133 DESIG=1
$\pi^+ \pi^-$	CPV [q] $(1.967 \pm 0.010) \times 10^{-3}$	S=1.5	206 DESIG=2
$\pi^0 \pi^0$	CPV $(8.64 \pm 0.06) \times 10^{-4}$	S=1.8	209 DESIG=5
Semileptonic modes with photons			
$\pi^\pm e^\mp \nu_e \gamma$	[f,o,r] $(3.79 \pm 0.06) \times 10^{-3}$		229 NODE=S013;CLUMP=C
$\pi^\pm \mu^\mp \nu_\mu \gamma$	$(5.65 \pm 0.23) \times 10^{-4}$		216 DESIG=12 DESIG=34
Hadronic modes with photons or $\ell\bar{\ell}$ pairs			
$\pi^0 \pi^0 \gamma$	$< 2.43 \times 10^{-7}$	CL=90%	209 NODE=S013;CLUMP=D
$\pi^+ \pi^- \gamma$	[f,r] $(4.15 \pm 0.15) \times 10^{-5}$	S=2.8	206 DESIG=33
$\pi^+ \pi^- \gamma$ (DE)	$(2.84 \pm 0.11) \times 10^{-5}$	S=2.0	206 DESIG=10
$\pi^0 2\gamma$	[r] $(1.273 \pm 0.033) \times 10^{-6}$		231 DESIG=50
$\pi^0 \gamma e^+ e^-$	$(1.62 \pm 0.17) \times 10^{-8}$		230 DESIG=13
Other modes with photons or $\ell\bar{\ell}$ pairs			
2γ	$(5.47 \pm 0.04) \times 10^{-4}$	S=1.1	249 NODE=S013;CLUMP=E
3γ	$< 7.4 \times 10^{-8}$	CL=90%	249 DESIG=9
$e^+ e^- \gamma$	$(9.4 \pm 0.4) \times 10^{-6}$	S=2.0	249 DESIG=45
$\mu^+ \mu^- \gamma$	$(3.59 \pm 0.11) \times 10^{-7}$	S=1.3	225 DESIG=14
$e^+ e^- \gamma\gamma$	[r] $(5.95 \pm 0.33) \times 10^{-7}$		249 DESIG=15
$\mu^+ \mu^- \gamma\gamma$	[r] $(1.0 \pm 0.8) \times 10^{-8}$		225 DESIG=23
Charge conjugation x Parity (CP) or Lepton Family number (LF) violating modes, or $\Delta S = 1$ weak neutral current (S1) modes			
$\mu^+ \mu^-$	S1 $(6.84 \pm 0.11) \times 10^{-9}$		225 DESIG=47
$e^+ e^-$	S1 $(9 \pm 6) \times 10^{-12}$		249 DESIG=6
$\pi^+ \pi^- e^+ e^-$	S1 [r] $(3.11 \pm 0.19) \times 10^{-7}$		206 DESIG=7
$\pi^0 \pi^0 e^+ e^-$	S1 $< 6.6 \times 10^{-9}$	CL=90%	209 DESIG=17
$\pi^0 \pi^0 \mu^+ \mu^-$	S1 $< 9.2 \times 10^{-11}$	CL=90%	57 DESIG=48
$\mu^+ \mu^- e^+ e^-$	S1 $(2.69 \pm 0.27) \times 10^{-9}$		225 DESIG=54
$e^+ e^- e^+ e^-$	S1 $(3.56 \pm 0.21) \times 10^{-8}$		249 DESIG=21
$\pi^0 \mu^+ \mu^-$	CP,S1 [s] $< 3.8 \times 10^{-10}$	CL=90%	249 DESIG=22
$\pi^0 e^+ e^-$	CP,S1 [s] $< 2.8 \times 10^{-10}$	CL=90%	177 DESIG=20
$\pi^0 \nu \bar{\nu}$	CP,S1 [t] $< 2.6 \times 10^{-8}$	CL=90%	230 DESIG=43
$\pi^0 \pi^0 \nu \bar{\nu}$	S1 $< 8.1 \times 10^{-7}$	CL=90%	231 DESIG=52
$e^\pm \mu^\mp$	LF [o] $< 4.7 \times 10^{-12}$	CL=90%	209 DESIG=8
$e^\pm e^\pm \mu^\mp \mu^\mp$	LF [o] $< 4.12 \times 10^{-11}$	CL=90%	225 DESIG=24
$\pi^0 \mu^\pm e^\mp$	LF [o] $< 7.6 \times 10^{-11}$	CL=90%	217 DESIG=36
$\pi^0 \pi^0 \mu^\pm e^\mp$	LF $< 1.7 \times 10^{-10}$	CL=90%	159 DESIG=53

 $K^*(892)$ $I(J^P) = \frac{1}{2}(1^-)$ $K^*(892)^\pm$ hadroproduced mass $m = 891.66 \pm 0.26$ MeV $K^*(892)^\pm$ in τ decays mass $m = 895.5 \pm 0.8$ MeV $K^*(892)^0$ mass $m = 895.81 \pm 0.19$ MeV (S = 1.4) $K^*(892)^\pm$ hadroproduced full width $\Gamma = 50.8 \pm 0.9$ MeV $K^*(892)^\pm$ in τ decays full width $\Gamma = 46.2 \pm 1.3$ MeV $K^*(892)^0$ full width $\Gamma = 47.4 \pm 0.6$ MeV (S = 2.2)

NODE=M018

NODE=M018M1;DTYPE=M

NODE=M018MCT;DTYPE=M

NODE=M018M2;DTYPE=M

NODE=M018W1;DTYPE=G

NODE=M018W5;DTYPE=G

NODE=M018W2;DTYPE=G

$K^*(892)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\pi$	~ 100 %		289
$K^0\gamma$	$(2.46 \pm 0.21) \times 10^{-3}$		307
$K^\pm\gamma$	$(9.9 \pm 0.9) \times 10^{-4}$		309
$K\pi\pi$	$< 7 \times 10^{-4}$	95%	223

NODE=M018220;DESIG=1;OUR EVAL;
 → UNCHECKED ←
 DESIG=4
 DESIG=3
 DESIG=2

 $K_1(1270)$

$$I(J^P) = \frac{1}{2}(1^+)$$

Mass $m = 1272 \pm 7$ MeV [u]

Full width $\Gamma = 90 \pm 20$ MeV [u]

$K_1(1270)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\rho$	(42 ± 6) %	46
$K_0^*(1430)\pi$	(28 ± 4) %	†
$K^*(892)\pi$	(16 ± 5) %	302
$K\omega$	(11.0 ± 2.0) %	†
$Kf_0(1370)$	(3.0 ± 2.0) %	†
γK^0	seen	539

NODE=M028

NODE=M028MX;DTYPE=M

NODE=M028WX;DTYPE=G;OUR EST;
 → UNCHECKED ←

 $K_1(1400)$

$$I(J^P) = \frac{1}{2}(1^+)$$

Mass $m = 1403 \pm 7$ MeV

Full width $\Gamma = 174 \pm 13$ MeV (S = 1.6)

$K_1(1400)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K^*(892)\pi$	(94 ± 6) %	402
$K\rho$	(3.0 ± 3.0) %	293
$Kf_0(1370)$	(2.0 ± 2.0) %	†
$K\omega$	(1.0 ± 1.0) %	284
$K_0^*(1430)\pi$	not seen	†
γK^0	seen	613

NODE=M064

NODE=M064M;DTYPE=M

NODE=M064W;DTYPE=G

 $K^*(1410)$

$$I(J^P) = \frac{1}{2}(1^-)$$

Mass $m = 1414 \pm 15$ MeV (S = 1.3)

Full width $\Gamma = 232 \pm 21$ MeV (S = 1.1)

$K^*(1410)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K^*(892)\pi$	> 40 %	95%	410
$K\pi$	(6.6 ± 1.3) %		612
$K\rho$	< 7 %	95%	305
γK^0	seen		619

NODE=M094

NODE=M094M;DTYPE=M

NODE=M094W;DTYPE=G

 $K_0^*(1430)$ [v]

$$I(J^P) = \frac{1}{2}(0^+)$$

Mass $m = 1425 \pm 50$ MeV

Full width $\Gamma = 270 \pm 80$ MeV

NODE=M094215;DESIG=2;OUR EST;
 → UNCHECKED ←
 DESIG=1

DESIG=3;OUR EST;→ UNCHECKED ←
 DESIG=4;OUR EST;→ UNCHECKED ←

NODE=M019

NODE=M019M;DTYPE=M;OUR EST;
 → UNCHECKED ←

NODE=M019W;DTYPE=G;OUR EST;
 → UNCHECKED ←

$K_0^*(1430)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(93±10) %	619

NODE=M019215;DESIG=1

 $K_2^*(1430)$

$$I(J^P) = \frac{1}{2}(2^+)$$

 $K_2^*(1430)^{\pm}$ mass $m = 1425.6 \pm 1.5$ MeV (S = 1.1) $K_2^*(1430)^0$ mass $m = 1432.4 \pm 1.3$ MeV $K_2^*(1430)^{\pm}$ full width $\Gamma = 98.5 \pm 2.7$ MeV (S = 1.1) $K_2^*(1430)^0$ full width $\Gamma = 109 \pm 5$ MeV (S = 1.9)

$K_2^*(1430)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$K\pi$	(49.9±1.2) %		619
$K^*(892)\pi$	(24.7±1.5) %		419
$K^*(892)\pi\pi$	(13.4±2.2) %		372
$K\rho$	(8.7±0.8) %	S=1.2	318
$K\omega$	(2.9±0.8) %		311
$K^+\gamma$	(2.4±0.5) × 10 ⁻³	S=1.1	627
$K\eta$	(1.5 ^{+3.4} _{-1.0}) × 10 ⁻³	S=1.3	486
$K\omega\pi$	< 7.2 × 10 ⁻⁴	CL=95%	100
$K^0\gamma$	< 9 × 10 ⁻⁴	CL=90%	626

NODE=M022

NODE=M022M1;DTYPE=M

NODE=M022M4;DTYPE=M

NODE=M022W1;DTYPE=G

NODE=M022W4;DTYPE=G

 $K^*(1680)$

$$I(J^P) = \frac{1}{2}(1^-)$$

Mass $m = 1717 \pm 27$ MeV (S = 1.4)Full width $\Gamma = 322 \pm 110$ MeV (S = 4.2)

NODE=M095

NODE=M095M;DTYPE=M

NODE=M095W;DTYPE=G

$K^*(1680)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(38.7±2.5) %	781
$K\rho$	(31.4 ^{+5.0} _{-2.1}) %	571
$K^*(892)\pi$	(29.9 ^{+2.2} _{-5.0}) %	618

NODE=M095215;DESIG=1

DESIG=3

DESIG=2

 $K_2(1770)$ [x]

$$I(J^P) = \frac{1}{2}(2^-)$$

Mass $m = 1773 \pm 8$ MeVFull width $\Gamma = 186 \pm 14$ MeV

NODE=M023

NODE=M023M;DTYPE=M

NODE=M023W;DTYPE=G

$K_2(1770)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi\pi$		794
$K_2^*(1430)\pi$	dominant	288
$K^*(892)\pi$	seen	654
$Kf_2(1270)$	seen	55
$K\phi$	seen	441
$K\omega$	seen	607

NODE=M023215;DESIG=1;OUR EST;
 \rightarrow UNCHECKED \leftarrow
 DESIG=2;OUR EST; \rightarrow UNCHECKED \leftarrow
 DESIG=4;OUR EST; \rightarrow UNCHECKED \leftarrow
 DESIG=9;OUR EST; \rightarrow UNCHECKED \leftarrow
 DESIG=10
 DESIG=8

 $K_3^*(1780)$

$$I(J^P) = \frac{1}{2}(3^-)$$

Mass $m = 1776 \pm 7$ MeV (S = 1.1)Full width $\Gamma = 159 \pm 21$ MeV (S = 1.3)

NODE=M060

NODE=M060M;DTYPE=M

NODE=M060W;DTYPE=G

$K_3^*(1780)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\rho$	(31 ± 9) %		613
$K^*(892)\pi$	(20 ± 5) %		656
$K\pi$	(18.8 ± 1.0) %		813
$K\eta$	(30 ± 13) %		719
$K_2^*(1430)\pi$	< 16 %	95%	291

 $K_2(1820)$ [ν]

$$I(J^P) = \frac{1}{2}(2^-)$$

Mass $m = 1816 \pm 13$ MeV
 Full width $\Gamma = 276 \pm 35$ MeV

$K_2(1820)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K_2^*(1430)\pi$	seen	327
$K^*(892)\pi$	seen	681
$Kf_2(1270)$	seen	186
$K\omega$	seen	638

 $K_4^*(2045)$

$$I(J^P) = \frac{1}{2}(4^+)$$

Mass $m = 2045 \pm 9$ MeV (S = 1.1)
 Full width $\Gamma = 198 \pm 30$ MeV

$K_4^*(2045)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(9.9 ± 1.2) %	958
$K^*(892)\pi\pi$	(9 ± 5) %	802
$K^*(892)\pi\pi\pi$	(7 ± 5) %	768
$\rho K\pi$	(5.7 ± 3.2) %	741
$\omega K\pi$	(5.0 ± 3.0) %	738
$\phi K\pi$	(2.8 ± 1.4) %	594
$\phi K^*(892)$	(1.4 ± 0.7) %	363

NODE=M146

NODE=M146M;DTYPE=M

NODE=M146W;DTYPE=G

NODE=M146215;DESIG=1;OUR EVAL;
 \rightarrow UNCHECKED \leftarrow
 DESIG=2;OUR EVAL; \rightarrow UNCHECKED \leftarrow
 DESIG=3;OUR EVAL; \rightarrow UNCHECKED \leftarrow
 DESIG=6;OUR EVAL; \rightarrow UNCHECKED \leftarrow

NODE=M035

NODE=M035M;DTYPE=M

NODE=M035W;DTYPE=G

NODE=M035215;DESIG=1
 DESIG=2
 DESIG=5
 DESIG=3
 DESIG=4
 DESIG=6
 DESIG=7

NOTES

- [a] See the note in the K^\pm Particle Listings.
- [b] The definition of the slope parameter g of the $K \rightarrow 3\pi$ Dalitz plot is as follows (see also “Note on Dalitz Plot Parameters for $K \rightarrow 3\pi$ Decays” in the K^\pm Particle Listings):
- $$|M|^2 = 1 + g(s_3 - s_0)/m_{\pi^+}^2 + \dots$$
- [c] See the “Note on $\pi^\pm \rightarrow \ell^\pm \nu \gamma$ and $K^\pm \rightarrow \ell^\pm \nu \gamma$ Form Factors” in the π^\pm Particle Listings for definitions and details.
- [d] For more details and definitions of parameters see the Particle Listings.
- [e] See the K^\pm Particle Listings for the energy limits used in this measurement.
- [f] Most of this radiative mode, the low-momentum γ part, is also included in the parent mode listed without γ 's.
- [g] Structure-dependent part.
- [h] Direct-emission branching fraction.
- [i] Derived from an analysis of neutrino-oscillation experiments.
- [j] Violates angular-momentum conservation.
- [k] Derived from measured values of ϕ_{+-} , ϕ_{00} , $|\eta|$, $|m_{K_L^0} - m_{K_S^0}|$, and $\tau_{K_S^0}$, as described in the introduction to “Tests of Conservation Laws.”
- [l] The CP -violation parameters are defined as follows (see also “Note on CP Violation in $K_S \rightarrow 3\pi$ ” and “Note on CP Violation in K_L^0 Decay” in the Particle Listings):
- $$\eta_{+-} = |\eta_{+-}| e^{i\phi_{+-}} = \frac{A(K_L^0 \rightarrow \pi^+ \pi^-)}{A(K_S^0 \rightarrow \pi^+ \pi^-)} = \epsilon + \epsilon'$$
- $$\eta_{00} = |\eta_{00}| e^{i\phi_{00}} = \frac{A(K_L^0 \rightarrow \pi^0 \pi^0)}{A(K_S^0 \rightarrow \pi^0 \pi^0)} = \epsilon - 2\epsilon'$$
- $$\delta = \frac{\Gamma(K_L^0 \rightarrow \pi^- \ell^+ \nu) - \Gamma(K_L^0 \rightarrow \pi^+ \ell^- \nu)}{\Gamma(K_L^0 \rightarrow \pi^- \ell^+ \nu) + \Gamma(K_L^0 \rightarrow \pi^+ \ell^- \nu)},$$
- $$\text{Im}(\eta_{+-0})^2 = \frac{\Gamma(K_S^0 \rightarrow \pi^+ \pi^- \pi^0)^{CP \text{ viol.}}}{\Gamma(K_L^0 \rightarrow \pi^+ \pi^- \pi^0)},$$
- $$\text{Im}(\eta_{000})^2 = \frac{\Gamma(K_S^0 \rightarrow \pi^0 \pi^0 \pi^0)}{\Gamma(K_L^0 \rightarrow \pi^0 \pi^0 \pi^0)}.$$
- where for the last two relations CPT is assumed valid, i.e., $\text{Re}(\eta_{+-0}) \simeq 0$ and $\text{Re}(\eta_{000}) \simeq 0$.
- [n] See the K_S^0 Particle Listings for the energy limits used in this measurement.
- [o] The value is for the sum of the charge states or particle/antiparticle states indicated.
- [p] $\text{Re}(\epsilon'/\epsilon) = \epsilon'/\epsilon$ to a very good approximation provided the phases satisfy CPT invariance.
- [q] This mode includes gammas from inner bremsstrahlung but not the direct emission mode $K_L^0 \rightarrow \pi^+ \pi^- \gamma$ (DE).
- [r] See the K_L^0 Particle Listings for the energy limits used in this measurement.
- [s] Allowed by higher-order electroweak interactions.
- [t] Violates CP in leading order. Test of direct CP violation since the indirect CP -violating and CP -conserving contributions are expected to be suppressed.

LINKAGE=KM

LINKAGE=SY

LINKAGE=SWK

LINKAGE=SXK

LINKAGE=KD+

LINKAGE=KX

LINKAGE=SH

LINKAGE=SJ

LINKAGE=CL

LINKAGE=AM

LINKAGE=CG

LINKAGE=SZ

LINKAGE=KDS

LINKAGE=SG

LINKAGE=SAA

LINKAGE=IBR

LINKAGE=KDL

LINKAGE=CE

LINKAGE=CD

- [u] This is only an educated guess; the error given is larger than the error on the average of the published values. See the Particle Listings for details.
- [v] See the "Note on $f_0(1370)$ " in the $f_0(1370)$ Particle Listings and in the 1994 edition.
- [x] See the note in the $L(1770)$ Particle Listings in Reviews of Modern Physics **56** S1 (1984), p. S200. See also the "Note on $K_2(1770)$ and the $K_2(1820)$ " in the $K_2(1770)$ Particle Listings .
- [y] See the "Note on $K_2(1770)$ and the $K_2(1820)$ " in the $K_2(1770)$ Particle Listings .

LINKAGE=MS

LINKAGE=NFO

LINKAGE=MDB

LINKAGE=MBD